UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D C 20230

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January 24, 2003

Mr. Edmond Thomas
Chief, Office of Engineering & Technology
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

01-185

Dear Mr. Thomas:

In our November 12, 2002 letter, we provided comments on the Federal Communication Commission's (FCC) *Notice of Proposed Rulemaking (NPRM) in the Matter of Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz, the L-Band, and 1.6/2.4 GHz Band.* In that letter, we recommended equivalent isotropically radiated power (EIRP) limits to protect Global Positioning System (GPS) receivers when used in both aviation and terrestrial scenarios.

In past proceedings, the National Telecommunications and Information Administration (NTIA) recommended EIRP limits of no higher than –40 dBm/MHz to protect GPS L1 reception in aviation scenarios for mobile satellite service (MSS) Mobile Earth Stations, 700 MHz commercial base stations and mobile transmitters, and 700 MHz public safety base stations and mobile transmitters. This emission limit was based on the only known safety of life application of GPS at the time, *i.e.*, for the aviation use of L1 case, and can also be applied to the MSS Ancillary Terrestrial Component (ATC) stations in the Big LEO, L-band and 2 GHz bands for aviation scenarios, If terrestrial scenarios involving safety of life applications of GPS in the L1 band, the L2 or any other frequency bands had been apparent during those rulemakings, NTIA would have used those scenarios in developing the emission limits.

At the 2000 World Radiocommunication Conference, a new allocation was adopted for the radio navigation satellite service (RNSS) in the 1164-1215 MHz frequency band. **As** part of the GPS modernization program, a new GPS signal for aviation and non-aviation applications, designated as L5, will be provided in the 1164-1188 MHz portion of the newly allocated RNSS band. In addition, a second signal similar in null-to-null bandwidth to the L1 coarse/acquisition (C/A) code signal will be provided in the GPS L2 frequency band of 1215-1240 MHz.[1] Therefore, in order to completely assess compatibility with the GPS operations, terrestrial receivers in the L1, L2, and L5 frequency bands should be analyzed. This was done for the first time during the FCC UWB rulemaking, which lead to the adoption of emission limits appropriate to the 2 meter separation distance in all three GPS bands.

1 The GPS Precision code (P-code) is currently transmitted in the 1215-1240 MHz band

The NTIA recommended limits for MSS ATC components (base station transmitters (BTS), pico base stations, and mobile terminals (MT)) in our November 12,2002 are shown in Attachment 1. The differences between the emission limits required for compatible operation with aviation and terrestrial GPS receivers can be attributed to the technical factors specific to each use. The aviation scenario considered an aircraft in the final phase of flight, during which the GPS receiver will be in the tracking mode of operation as opposed to the more sensitive acquisition mode of operation. The GPS signals seen by the aircraft receive antenna are essentially unobstructed. The interfering transmitter is located on the ground 30 meters directly beneath the aircraft and (because of aircraft shielding) an effective antenna gain of – 10 dBi in the direction of the interfering transmitter was used in the analysis.

On the other hand, GPS receivers in the terrestrial scenario make use of signals which are barely above the receiver's tracking and acquisition thresholds, the antenna gain is typically 0 dBi, and distance separations between unconstrained interferers (*e.g.*, mobile hand-held devices, local area networks) on the order of 2 meters can occur. The technical factors when considering interference to GPS receivers in the aviation and terrestrial scenarios are clearly very different, and emission limits based on aviation applications will not protect terrestrial applications of GPS from received interfering signal levels above the acceptable level at separation distance less than 30 meters from the MSS ATC stations. NTIA believes that our goal must be to protect those critical terrestrial applications of GPS and that the emission limits should be based on desired signal levels, distance separations and antenna couplings consistent with this use.

The most stringent EIRP limits on ATC shown in Attachment 1 are those based on a 2-meter separation between the MT and GPS receiver. Other separation distances and resulting EIRP limits on the MT are shown. If the protection distance were increased to ***6*** meters, the EIRP limits could be raised by 10 dB, or for the MT in the L1 band from -75 dBm/MHz to -65 dBm/MHz. If the protection distance were increased to 107 meters, the EIRP limit would be -40 dBm/MHz. In all of these scenarios, the MT is assumed to be in use by a person at the same time a second person within the protection distance was making a wireless, assisted E-91 1 under emergency conditions.

We have made some preliminary calculations shown in Attachment 2 to determine the effect that various EIRP limits would have on the ability of the GPS receivers to meet the FCC's E91 1 performance accuracy requirement of 150 meters with 95 % availability. Based on this analysis, it would appear that the -40 dBm/MHz would cause this performance availability to be significantly degraded. However, an EIRP of -65 dBm/MHz would stay within the FCC availability constraint. Moreover, at the -75 dBm/MHz level, the availability rate would be very high. Therefore, to maintain the desired performance availability, the EIRP limit for the MSS ATC mobile terminal should be -65 dBm/MHz.

On July 17, 2002 the GPS Industry Council and MSV jointly submitted an *ex parte* agreement to the FCC specifying that the MSV ATC base stations will "[u]se filtering to achieve -100 dBW/MHz [-70 dBm/MHz], or lower" emissions in the 1559-1605 MHz frequency band. Also, the *ex parte* filing states that the ATC Terminals will "[u]se filtering to achieve -90 dBW/MHz [-60 dBm/MHz], or lower, in [the] short-term" and will "migrate to -95 dBW/MHz [-65 dBm/MHz], or lower, for new terminals in 5 years (from the date MSV service is operational)" for emissions in the 1559-1605 MHz band. Thus, it would appear that limits much more stringent than –40 dBm/MHz are attainable by the MSS ATC communities and agreeable with the GPS community.

NTIA believes that the protection of safety-of-life aviation and safety related terrestrial services is essential and suitable accommodation should be made. We are veryreluctant and concerned to any relaxation of the emission level limits in the GPS bands that would seriously limit the many critical uses of terrestrial GPS services. We will work closely with the FCC to ensure that proper consideration is given to protection of the terrestrial GPS service.

Sincerely,

Fredrick R. Wentland
Acting Associate Administrator
Office of Spectrum Management

2 Attachments

A[illegible]ment 1
on MSS ATC Components (Wideband Emissions)
(November 12, 02)

Scenario	GPS Band	MSS ATC Comp	GPS Rx Ht (m)	Tx Ht (m)	GPS to Tx Hor Dist (m)	Slant Rng (m)	GPS Rx Interf Susc Lvl (dBm/MHz)	Prop Loss (dB)	GPS Rx Ant Gain (dBi)	Interf Allot (dB)	Avaition safe mar-gin (dB)	Mult BTS Carr (dB)	Bldg Loss (dB)	Ant Gain Red (dB)	Avail Margi n (dB)	No. of Act ATC Eqts	Max. EIRP (dBm/ MHz)
Terrestrial	L1	BTS	1.5	15	100	111	-117	76.5	0	-3		-4.8		.5		1	-47.8
	L2		1.5	15	100	111	-117	74.3	0	-3		-4.8		.5		1	-50
	L5		1.5	15	100	111	-117	73.9	0	-3		-4.8		.5		1	-50.4
	L1		1.5	30	150	153	-117	80.1	-3	-3		-4.8		3		1	-44.7
	L2		1.5	30	150	153	-117	77.9	-3	-3		-4.8		3		1	-46.9
	L5		1.5	30	150	153	-117	77.5	-3	-3		-4.8		3		1	-47.3
	L1	Pico	1.5	5	5	6	-117	52.1	-3	-3						1	-70.9
	L2		1.5	5	5	6	-117	50	-3	-3						1	-73
	L5		1.5	5	5	6	-117	49.6	-3	-3						1	-73.4
	L1	MT			2		-117	42.4	0							1	-74.6
	L2				2		-117	40.3	0							1	-76.7
	L5				2		-117	39.8	0							1	-77.2
Aviation	L1	MT			30		-110.5	65.9	10	-3	-6					1	-43.6
Aviation	L5				30		-110.5	63.4	10	-3	-6					1	-46.1
Aviation - A/C in rte	L1	Mult BTS	300	30		270	-116.5	-84.9	-10	6	6		-2.5	-30	38.9	863	-40
Aviation - A/C in rte	L5		300	30		270	-116.5	-82.5	-10	6	6		-2.5	-30	36.5	496	-40
Aviation - A/C in rte	L1		300	30		270	-116.5	-84.9	-10	6	6		-2.5	-30	43.6	2545	-44.7
Aviation - A/C in rte	L5		300	30		270	-116.5	-82.5	-10	6	6		-2.5	-30	43.8	2665	-47.3
Aviation - A/C in prec appr landing	L1	BTS	500 ft from run-way	30		150	-110.5	79.9	4.5	-6	-6	-4.8		2			-40.9
Aviation - A/C in prec appr landing	L5	BTS	500 ft from run-way	30		150	-110.5	77.4	4.5	-6	-6	-4.8		2			-43.4

Maximum allowable EIRP of the Mobile Terminal = GPS Rx Interference Susceptibility Level + Propagation Loss (20 Log F +20 Log D -27.55) + GPS Rx Antenna Gain

GPS Link	GPS Rx Interference Susceptibility Level (dBm/MHz)	Frequency (MHz)	Distance (meters)	GPS Rx Antenna Gain	Radiowave propagation Loss (dB)	Maximum Allowable EIRP (dBm/MHz)	Difference (dB)
L1	-117	1575.42	2	0	42.4	-74.6	
	-117	1575.42	3	0	45.9	-71.1	3.5
	-117	1575.42	4	0	48.4	-68.6	2.5
	-117	1575.42	5	0	50.4	-66.6	1.9
	-117	1575.42	6	0	52.0	-65.0	1.6
	-117	1575.42	7	0	53.3	-63.7	1.3
	-117	1575.42	8	0	54.5	-62.5	1.2
	-117	1575.42	9	0	55.5	-61.5	1.0
	-117	1575.42	10	0	56.4	-60.6	0.9
	-117	1575.42	15	0	59.9	-57.1	3.5
	-117	1575.42	20	0	62.4	-54.6	2.5
	-117	1575.42	25	0	64.4	-52.6	1.9
	-117	1575.42	30	0	65.9	-51.1	1.6
	-117	1575.42	107	0	77.0	-40.0	11.0

Attachment 2

<u>Failure Rate Analysis</u>

The failure rate of any system can be defined as follows:

Failure Rate = Number of Failures/Number of Trials

For communication systems the failure rate *is* expressed in terms of the bit error rate which is calculated as follows:

Bit Error Rate = Number of Bits in Error/Number of Bits Sent

The number of error bits *is* a function of the number of bits sent. An increase in bit error rate can be apportioned to different causes (e.g., momentary equipment failures, variations in propagation, or interference).

The aviation community describes failure rate in terms of Hull Loss during landings which is calculated as follows:

Hull Loss (landing) =Number of Aircraft Lost/ Number of Landings

Hull Loss can also be apportioned to different causes such as electronic failures or hydraulic failures. This can be further apportioned to individual components (e.g., hydraulic line failure).

The failure rate of GPS receivers used in urban environments can also be calculated in a similar manner. the case of GPS the failure rate is defined in terms of an increase in the receiver noise floor ($I/N = -6$ dB) for a GPS receiver operating at a minimum C/N_0 for at least one of the satellites required for a location solution. The number of failures for a GPS receiver operating in an urban environment can be calculated as follows:

$$\text{Number of Failures} = (N_{GPS})\,(P_{I/N=-6})\,(P_{C/N})$$

where :

N_{GPS} is the number of GPS uses;
$P_{I/N=-6}$ is the probability of causing an $I/N = -6$ dB;
$P_{C/N}$ is the probability of operating at a minimum C/N_0.

The failure rate is then calculated as follows:

$$\text{Failure Rate} = \text{Number of Failures}/\text{ Number of GPS Uses} = (P_{I/N=-6})\,(P_{C/N})$$

If a ATC base station (BS) coverage defined by a 1 km radius is considered, the probability of causing an $I/N = -6$ dB can be computed as follows:

$$P_{I/N=-6} = (\pi\,(R_{GPS})^2/\,\pi\,(R_{BS})^2/3)\,N_{MT}$$

ere

R_{BS} is the radius of the ATC BS (m);
R_{GPS} is the protection radius for the GPS Receiver (m);
N_{MT} is the number of ATC mobile terminals operating in a 120 degree sector of the ATC base station

coverage area.

The protection radius of the GPS receiver is computed using the following equation:

$$R_{GPS} = 10^{(-It + EIRP + Gr - 20 \text{ Log } F + 27.55)/20}$$

where:

It is the GPS receiver susceptibility level (dBm/MHz);
EIRP is the equivalent isotropically radiated power level of the transmitter (dBm/MHz);
Gr is the GPS receive antenna gain (dBi);
F is the GPS frequency (MHz)

Using the equation above the GPS protection radius for L1 receivers as a function of transmitter EIRP is shown in Table 1:

(dBm/MHz)	(dBm/MHz)	(dBi)		(m)
-117	-75	0	-36.4	1.9
-117	-65	0	-36.4	6.1
-117	-55	0	-36.4	19.2
-117	-45	0	-36.4	6C.6
-117	-40	0	-36.4	107.8

The Probability of Operating at a Minimum C/N_0 was determined from measurements performed by Qualcomm.[2] **A** value of 5% (.05) is considered in this analysis.

Similar to the examples provided earlier, the overall GPS failure rate can be apportioned to different sources such as low desired signal levels, blockage from obstructions, and interference. The remainder of this analysis will consider the portion of the failure rate that results from interference.

Analysis Example

The GPS failure rate that can be attributed to interference must consider the potential multiple interfering sources that can occur in an urban operating environment such as: 1) ATC MTs of multiple service providers, 2) 700 MHz commercial and public safetymobile and portable transmitters, and 3) UWB handheld devices.

If an overall failure rate for GPS receivers of 5% (95% availability) is considered and 40% of this can be attributed lo interference then the failure rate for interference is 2% (0.02).[3]

700 MHz commercial and public safety mobile and portable transmitters are permitted *to* operate at an EIRP of –40 dBm/MHz in the 1559-1605 MHz band used by GPS. As shown in Table 1 this EIRP equates to a GPS protection radius of 107.8 **m.** If it is assumed that there 10 of these devices operating within the ATC BS sector the GPS failure rate is[4]:

Qualcomm Written **Ex** Parte Presentation ET Docket No. 98-253 (Jan. 11, 2002) at pg.13 Figure 3-6.

[3] The Commission specifies E911 performance in terms of an accuracy of 150 m with 95% availability This indicates that 5% of the time this accuracy requirement will not be achieved.

[4] The value of 10 devices underestimates the number of devices, there could be more devices operating but it is assumed that the propagation loss in urban environments will reduce the distance to less than 107.8 m.

Failure Rate (700 MHz Equipment)= 10(0.0348)(0.05) = 0.0174

UWB handheld UWB devices are permitted to operate at an EIRP of -75 dBm/MHz in the 1559-1610 MHz band used by GPS. As shown in Table 1 this EIRP equates to a GPS protection radius 1.9 m. If it is assumed that there are 100 UWB devices operating in the ATC BS sector the GPS failure rate is:

Failure Rate (UWB Hand Held) = $100(1.925\text{x}10^{-5})(0.05) = 5.5\text{x}10^{-5}$

If ATC MTs operate at an EIRP limit of -65 dBm/MHz in the 1559-1605 MHz band a GPS protection radius 6 m is necessary. Assuming that there are three possible service providers (e.g., Big LEO, 2 GHz, and L-Band) each with 21 MTs in the **ATC** BS sector, the GPS failure rate is:

Failure Rate (ATC MT) = $21 \text{ x } 3 \text{ x } (0.0001102)(0.05) = 3.5\text{x}10^{-4}$

The total failure rate is calculated *from* the sum of the individual failure rates:

GPS Failure Rate = $0.0174 + 5.5\text{x}10^{-5} + 3.5\text{x}10^{-4} = 0.018$

The failure rate of 0.018 is slightly below the 0.02 allocated for interference. This leaves a small margin for GPRs, through wall imaging systems, ATC BSs, and MSS handsets.

If however, the ATC MT is permitted to operate at an EIRP of –40 dBm/MHz the GPS protection radius increases from 6 m to 107.8 m and the GPS failure rate is:

Failure Rate (ATC MT) = $3 \text{ x } 21 \text{ x } (0.0348435)(0.05) = 0.1098$

This number alone is larger than *the* 5% allowed for the total GPS failure rate.